Claims

1. A method of fabricating a three-dimensional structure from an etchable substrate, the method comprising the steps of:

specifying a unit cell size for a plurality of unit cells, each unit cell corresponding to an area on a mask;

generating a plurality of measurement values, each measurement value corresponding to a portion of the structure, each measurement value associated with a specific unit cell;

converting the plurality of measurement values to a plurality of unit cell fill factor values;

generating a gray tone data set in response to the unit cell fill factor values,

the gray tone data set comprising

a plurality of distinct rectangular areas and distinct square areas, each distinct area corresponding to a unique gray tone level,

adjusting the size and number of square and rectangular areas to increase the available number of unique gray tone levels; and

creating the mask in response to the gray tone data set such that at least a portion of the plurality of rectangular and square areas are disposed on the mask.

2. The method of claim 1 further comprising the step of etching a pattern of non-overlapping three-dimensional photoresist volumes disposed on the substrate, the pattern of photoresist volumes generated in response to the areas on the mask.

3. The method of claim 1 wherein the measurement values comprise height values measured at specific points on a surface of the three-dimensional structure.

4. The method of claim 1 wherein the step of converting the plurality of measurement values uses selectivity data, photoresist contrast data, and exposure data.

5. The method of claim 1 wherein the step of adjusting the size and number of square and rectangular areas comprises calculating at least a portion of the rectangular and square geometries that can fit within a unit cell.

6. The method of claim 5 further comprising the step of eliminating rectangular and square areas that exceed a specified aspect ratio.

7. The method of claim 5 further comprising the step of eliminating rectangular and square areas having a dimension smaller than a minimum spot size of a mask write tool.

8. The method of claim 1 wherein the photoresist volumes are mesa structures.

9. The method of claim 1 wherein the gray tone data set comprises shapes that differ in area as a result of an increase in the length or width of the of the shape.

10. A method of increasing available graytone levels for use in a lithographic process, the method comprising:

determining a unit cell size in response to a designed part geometry;

generating a set of distinct quadrilateral areas such that each area fits within a unit cell;

removing redundant quadrilateral areas from the set,

associating each graytone level with a distinct quadrilateral area; and

correlating each graytone level with a distinct unit cell fill factor.

11. The method of claim 10 wherein the set of distinct quadrilateral areas comprises a first set of square areas and a second set of rectangular areas.

12. The method of claim 10 wherein the set of distinct quadrilateral areas comprises shapes that monotonically increase in area by incrementing the either the length or width of the quadrilateral area by one unit quantity.

13. The method of claim 10 wherein all distinct quadrilateral areas that fit within a unit cell are associated with a graytone level.

14. The method of claim 13 wherein quadrilateral areas having a dimension smaller than the minimum spot size of a mask write tool are removed from the set.

15. A lens fabricated using a grayscale lithographic process, the process comprising the steps of:

generating a pattern of three-dimensional photoresist structures on a substrate using a mask, the mask comprising a plurality of regions populated by rectangular and square areas; and

etching the photoresist and substrate, thereby generating a lens.

16. The lens of claim 15 wherein the lens has a lens diameter ranging from about 5 μm to about 1 cm.

17. The lens of claim 15 wherein aspect ratios of the rectangular and square areas are restricted to reduce surface defects in the lens.

18. The lens of claim 15 wherein the required smoothness of the lens surface determines the number and size of the distinct square and rectangular areas disposed on the mask.

19. The lens of claim 15 wherein a portion of the regions are substantially concentric.

20. A diffraction grating produced using a lithography process, the lithography process comprising the steps of:

generating a mask having a periodic arrangement of a plurality of selectively filled unit cells, each unit cell partially filled with a fractional area selected from a set of square and rectangular areas, each area corresponding to a gray tone level;

depositing a photoresist layer on a substrate;

exposing the photoresist layer to radiation selectively transmitted by the areas of the mask;

developing the photoresist layer such that a periodic arrangement of photoresist mesa structures result; and

etching the mesa structures and substrate.

21. The grating of claim 20 wherein the grating spacing ranges from about 5 μm to about 1 cm.